

ASSESSMENT OF SOIL EROSION IN SUKHANA BASIN USING, USLE, GIS AND REMOTE SENSING: A CASE STUDY

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ABSTRACT

Geographical information system helped considerably in organizing the spatial data representing the effects of each factor affecting soil erosion. The Universal Soil Loss Equation (USLE) parameters were assessed using Remote Sensing (RS) and GIS for assessment of soil erosion in of Sukhana Basin of Aurangabad District, Maharashtra state. Rainfall erosivity factor (R) ranges from 423.26 to 623.79. The soil erodibility factor (K) for the ranges from 0.10 - 0.30, based on the soil texture class. The LS values of the study area ranges in between 0.5 - 5.5. The C-value of the study area ranges from 0.024 to 0.58. The P values ranges from 0.55-1.00. Based on USLE parameters and further analysis show that out of 35 sub watersheds in Sukhana basin 5 watersheds i.e. 1, 3, 28, 33, 35 are under severe erosion where as 9 watersheds 2, 8, 10, 15, 16, 30, 31, 32, 34 are under moderate erosion. Three sub watersheds namely 11, 18, 19 are under slight erosion and remaining sub watersheds 18 are under slight erosion.

KEYWORDS: Usle, Gis. Remote Sensing. Soil Erosion. Dem

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INTRODUCTION

Soil erosion by water is one of the most important land degradation problems and a critical environmental hazard. Geographical information system helped considerably in organizing the spatial data representing the effects of each factor affecting soil erosion. Soil erosion is a silent killer converting fertile lands into barren patches thus accelerating the runoff velocities to further aggravate the erosion cycle [17]. Remote Sensing provides a convenient technique to solve this problem. Remote Sensing (RS) and Geographic information System (GIS) enable manipulation of spatial data of various types. The ability to extract overlay and delineate any land characteristics make GIS suitable for soil erosion modelling [15].

Rainfall-runoff relationship is determined using USDA Soil Conservation Service (SCS) method. The coefficient of determination (R^2) is 0.99, which indicates a high correlation between rainfall and runoff. The runoff potential map was prepared by assigning individual class weight and scores input map. Annual spatial soil loss estimation was computed using Morgan, Morgan and Firmey mathematical model in conjunction with remote sensing and GIS techniques [8]. Assessment of soil erosion risk using GIS and RUSE with STATSGO and SSURGO soil database. Soil, land use, digital elevation, flow accumulation and climatic data are used to generate RUSLE variables [27].

Estimated annual sediment yield for, Karso watershed of Hazaribagh, Jharkhand State, India was divided into 200×200 grid cells and average annual sediment yields were estimated for each grid cell of the watershed to

identify the critical erosion prone areas of watershed for prioritization purpose. On grid basis was estimated using Universal Soil Loss Equation (USLE). The Arc Info 7.2 GIS software and RS (ERDAS IMAGINE 8.4 image processing software) provided spatial input data to the erosion model, while the USLE was used to predict the spatial distribution of the sediment yield on grid basis [2].

A GIS-based method has been applied for the determination of soil erosion and sediment yield in a small watershed in Mun River basin, Thailand. The method involves spatial disintegration of the catchment into homogenous grid cells to capture the catchment heterogeneity. The gross soil erosion in each cell was calculated using Universal Soil Loss Equation (USLE) by carefully determining its various parameters [18]. The Universal Soil Loss Equation (USLE) is an erosion model to estimate average soil loss that would generally result from splash, sheet, and rill erosion from agricultural plots, has been extended as a useful tool predicting soil losses and planning control practices in agricultural watersheds by the effective integration of the GIS-based procedures to estimate the factor values in a grid cell basis [5],[6],[28].

A Geographical Information System (GIS) based method is proposed and demonstrated for the identification of sediment source and sink areas and the prediction of sediment yield from watersheds [12]. Developed, New procedures, based on geographic information systems GIS to estimate the slope length in hydrographic basins [9]. Revised Universal Soil Loss Equation (RUSLE) and a geographic information system (GIS) for assessment of erosion hotspots, for a watershed. Using GIS [1], [26]

As maximum villages in the study area are selected for water conservation works under Jalyukt shiwar yojana by state government of Maharashtra. To decide the erosion status of the Sukhana Basin with the help of USLE, RS, and GIS, so that assessment is considered for planning of soil and water conservation works.

MATERIALS AND METHODS

Study Area

Geographical information system and remote sensing and USLE model used for assessment of soil erosion of Sukhana Basin, which is divided into 35 sub watersheds of Aurangabad District, Maharashtra state. Study area is located between 75.33°, 75.76° E longitudes, and 19.66°, 19.98° N latitudes. Study area covers 93 villages. Details of study area is given in table 1

Table 1: Summary of Study Area

Name of Watershed	No of Watershed	Area of Watershed in Sqkm	No .of Villages Covered
AU/GP-10	09	351.75	52
AU/GP-17'	06	172.25	32
AU/GP-17	02	66.00	09
Total---03	17	590.00	93

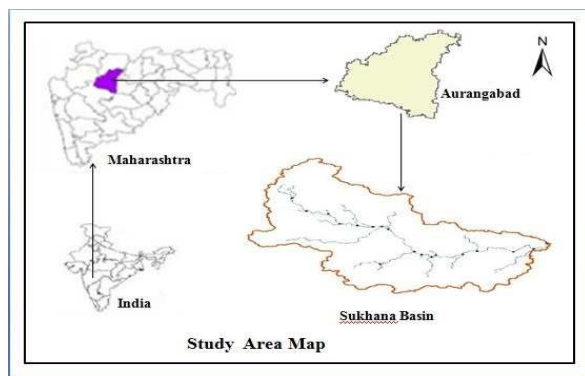


Figure 1: Study Area Map

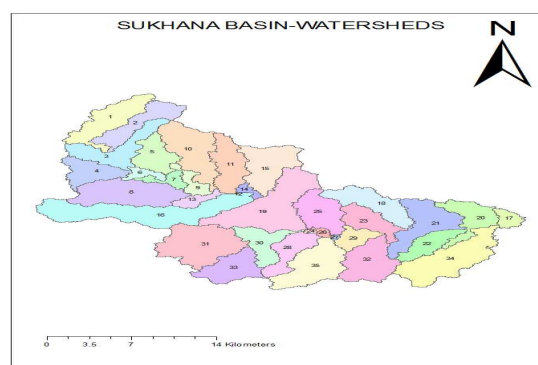


Figure 2: Sub Water Shed Map

Data Used

Spatial data consists of toposheets of Survey of India, satellite image and DEM of study area, state and district map for exact location of study area, Details of data shown in table 2.

Table 2: Data Details

Sr. No.	Type of Data	Source
1.	Study area map	Ground Water Survey Development Authority (GSDA)
2.	Toposheets	Survey of India department
3.	Satellite image	www.earthexplorer.in
4.	Soil type	NBSS, Nagpur Maharashtra
5.	Precipitation	www.globalweather.tamu.edu

Procedure Adopted

Study area has been clipped from digital elevation model. Sink are identified and filled to get corrected DEM. Rainfall erosivity factor (R) calculator from mean annual rainfall. Slope length and slope steepness (LS) factor calculated from DEM. Crop Management factor (C) calculated by repairing land use / land cover map and NBSS manual. K factor is calculated from soil map and NBSS manual. P factor calculated by reclassifying slopes and manual. Methodology also explained in flow chart figure.3.

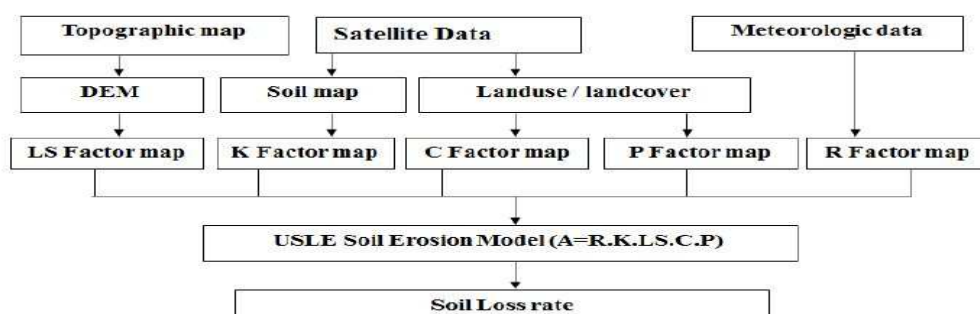


Figure 3: Methodology Flow Chart

RESULTS AND DISCUSSIONS

Soil Loss Equation

Universal Soil Loss Equation (Wischmeier and Smith, 1978) is a very widely accepted model for assessing the soil erosion. It computes the soil loss for a given site as a product of six major factors and is expressed by $A = R K L S C$

P Where R is rainfall erosion factor, K is the soil erodibility factor, L is the slope length factor, S is the slope steepness factor, C is the cropping management factor and P is the conservation factor. While L and S can be conveniently evaluated through GIS and DEM, the evaluation of other factors is done through empirically based equations and manual.

Rainfall Erosion Factor (R)

The rainfall distribution is not homogeneous all over the study area, for this reason an interpolation of annual precipitation data was applied to have a more representative rainfall distribution. Once the interpolation is performed a map representing annual rainfall in the region is obtained. This map was the input source for the R factor calculation using Singh et al. 1981 .

Rfactor = $79 + 0.363 \text{ MAR}$, Where MAR-Mean annual rainfall (mm).

Table 3: Details of R-Factor Reachwise

Sr. No.	Basin Reach	R-Factor
1.	Upper reach of basin	423.20-468.73
2.	Middle reach of basin	468.73-516.65
3.	Lower reach of basin	516.65-623.79

R factor ranges from 423.26 – 623.79 mm

Soil Erodibility Factor (K)

Erodibility accounts for the resistance of the soil to both detachment and transport. Although soil resistance to erosion depends in part on topographic position, slope steepness, cover and the amount of disturbances created by man . Soil erodibility (K) represents the susceptibility of soil or surface material to erosion, transportability of the sediment, and the amount and rate of runoff given a particular rainfall input, as measured under a standard condition. K factor values ranges from 0.1 to 0.3 which is shown in figure 4.

Slope Length Factor (L) And Slope Gradient Factor (S)

The effect of slope length and gradient on the intensity of the erosion process are significant for deciding the type and location of erosion control measures. Their effect is collectively called the topographic factor represented by “LS”. The slope length and slope steepness can be used in a single index, which expresses the ratio of soil loss as defined by (Wischmeier and Smith 1978)

$$LS = (X/22.1)^m (0.065 + 0.045 S + 0.0065 S^2)$$

Where X = slope length (m) and S = slope gradient (%)

The values of X and S were derived from DEM. To calculate the X value, Flow Accumulation was derived from the DEM after conducting Fill and Flow Direction.

$$X = (\text{Flow accumulation} * \text{Cell value})$$

By substituting X value, LS equation will be:

$$LS = (\text{Flow accumulation} * \text{Cell value} / 22.1)^m (0.065 + 0.045 s + 0.0065 s^2)$$

DEM of study area is shown in figure 5(a) and LS factor map shown in figure 5 (b).

Cropping Management Factor (C)

The land cover intercepts the rainfall, increase the infiltration and reduce the rainfall energy. The land cover is the parameter more influenced by the hand man and your impact increase the erosion. Different land use/land cover classes like urbanization Barren land, Settlement, Forest land, Water body, Agricultural land. etc. Then identified using visual interpretation keys such as colour, tone, texture, pattern, size and shape. Supervised classification technique, three images with different years are independently classified. A supervised classification method was carried out using 8 to 10 training sites were made by demarcating a polygon or an area of interest for all the five land use and land cover types. Then for each class average signature was developed. Data is also for accuracy assessment. Maximum Likelihood Algorithm was employed to detect the land cover types in ERDAS Imagine 9.1. Crop management factor are shown in figure 6.

Conservation Practice Factor

The P factor depends not only on the type of treatment or practices adopted but also on the slope of the field. To generate the P factor coverage, slope map is reclassified and P values are assigned to each slope class as shown in figure 7.

Soil Erosion Assessment

The above raster maps of R, K, L, S, C and P, were integrated using USLE model. Raster calculator tool in spatial analyst in ArcGIS software for assessment the soil loss. Erosion status in different sub watersheds in basin is shown in table 4. And also shown in figure 8.

Table 4: Watershed Wise Erosion Status of Sukhana Basin

Subwatershed	Erosion (T/Ha/Yr)	Status
1	21	severe
2	18	moderate
3	20	severe
4	5	very slight
5	0	very slight
6	0	very slight
7	0	very slight
8	13	moderate
9	0	very slight
10	15	moderate
11	7	slight
12	0	very slight
13	5	very slight
14	0	very slight
15	10	moderate
16	13	moderate
17	0	very slight
18	7	slight
19	6	slight
20	1	very slight
21	1	very slight
22	0	very slight
23	2	very slight
24	0	very slight
25	4	very slight
26	0	very slight
27	0	very slight

Table 4: Contd.,		
28	23	severe
29	0	very slight
30	10	moderate
31	12	moderate
32	13	moderate
33	21	severe
34	14	moderate
35	21	severe

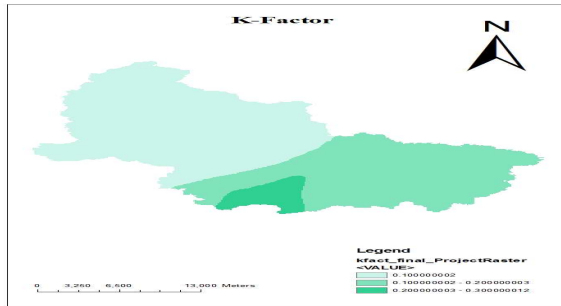


Figure 3: K Factor Map

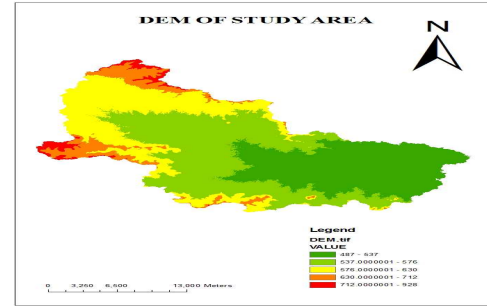


Figure 4: DEM Map

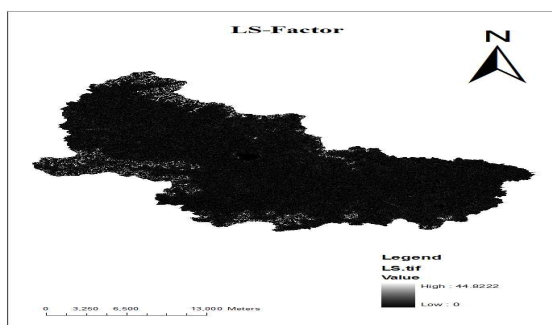


Figure 5: LS Factor Map

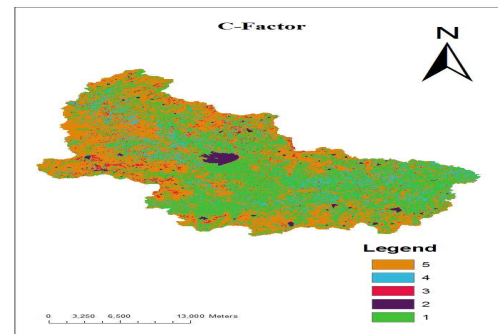


Figure 6: Factor Map

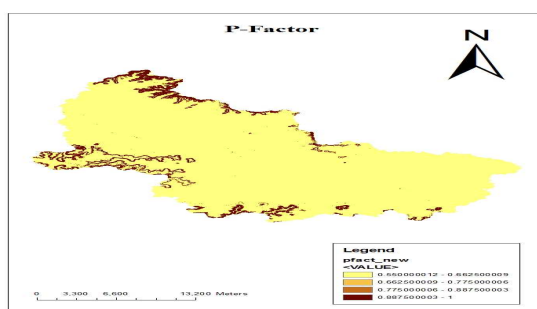


Figure 7: P Factor Map

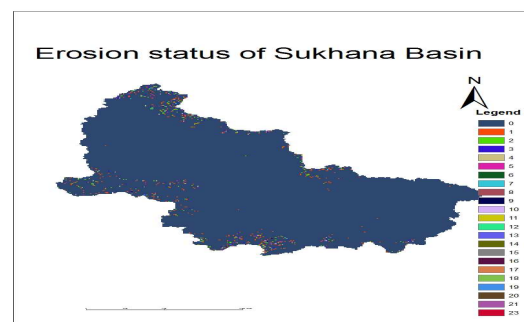


Figure 8: Erosion Status Map

Based on the integration of R,K, LS, C & P factors in GIS. Four classes of actual soil loss were identified. Analysis shows that sub watershed 5 no. 1, 3, 28, 33 and 35 have loss more than 20 t/ha/year hence class categories under severe erosion.

Nine sub watersheds of 2,8,10,15,16,30,31,32,34 have erosion between 10-20 t/ha/yr hence categories under moderate erosion. Watershed which having erosion less than 5-10 t/ha/yr are 3 watershed 11,18,19 have slight erosion and

remaining 18 watersheds 4,5,6,7,9,12,13,14,17,20,21,22,23,24,25, 26, 27, 29 have erosion in the range of 0-5 t/ha/hr hence categories under very slight erosion status.

CONCLUSIONS

Based on USLE parameters and analysis show that out of 35 sub watersheds in Sukhana basin 5 watersheds i.e. 1, 3,28,33,35 are under severe erosion where as 9 watersheds 2,8,10,15,16,30,31,32,34 are under moderate erosion. Three sub watersheds namely 11, 18, 19 are under slight erosion and remaining sub watersheds 18 are under slight erosion.

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